Welcome
to
DARPA/TTO's Proposers' Day

April 29-30, 2015

DARPA

TTO Highlights

Tactical Technology Office

Dr. Bradford C. Tousley, Director

Briefing prepared for TTO Proposers Day

April 29, 2015

Mission

The Defense Advanced Research Projects Agency (DARPA) was established in 1958 to **prevent strategic surprise** from negatively affecting U.S. national security and **create strategic surprise** for U.S. adversaries by maintaining the technological superiority of the U.S. military.

To fulfill its mission, the Agency relies on **diverse performers** to apply multi-disciplinary approaches to both advance knowledge through basic research and **create innovative technologies** that address current practical problems through applied research.

As the DoD's **primary innovation engine**, DARPA undertakes projects that are finite in duration but that create **lasting revolutionary change**.

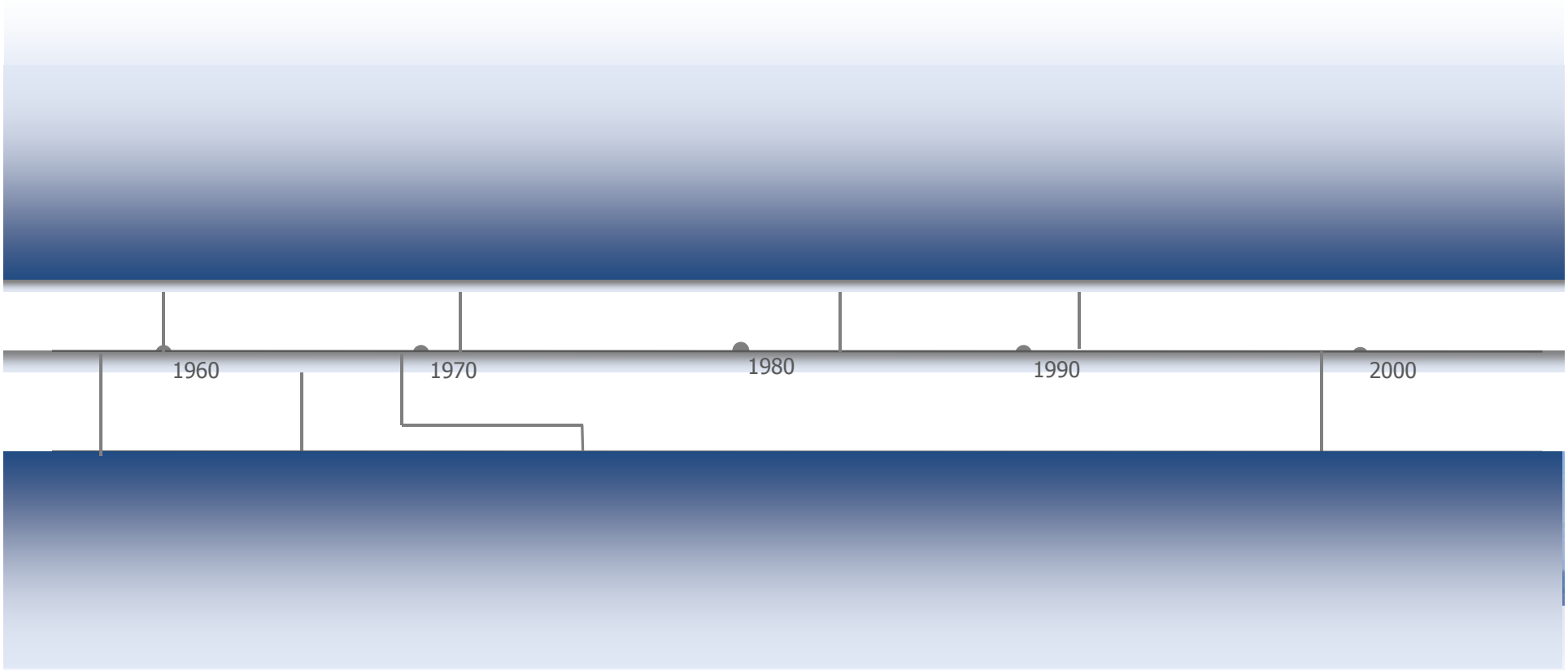
DARPA History

SATURN F1 Rocket Engine
1960

Speech Recognition
1971

Stealth Fighter
1983

Microelectromechanical Systems (MEMS)
1991



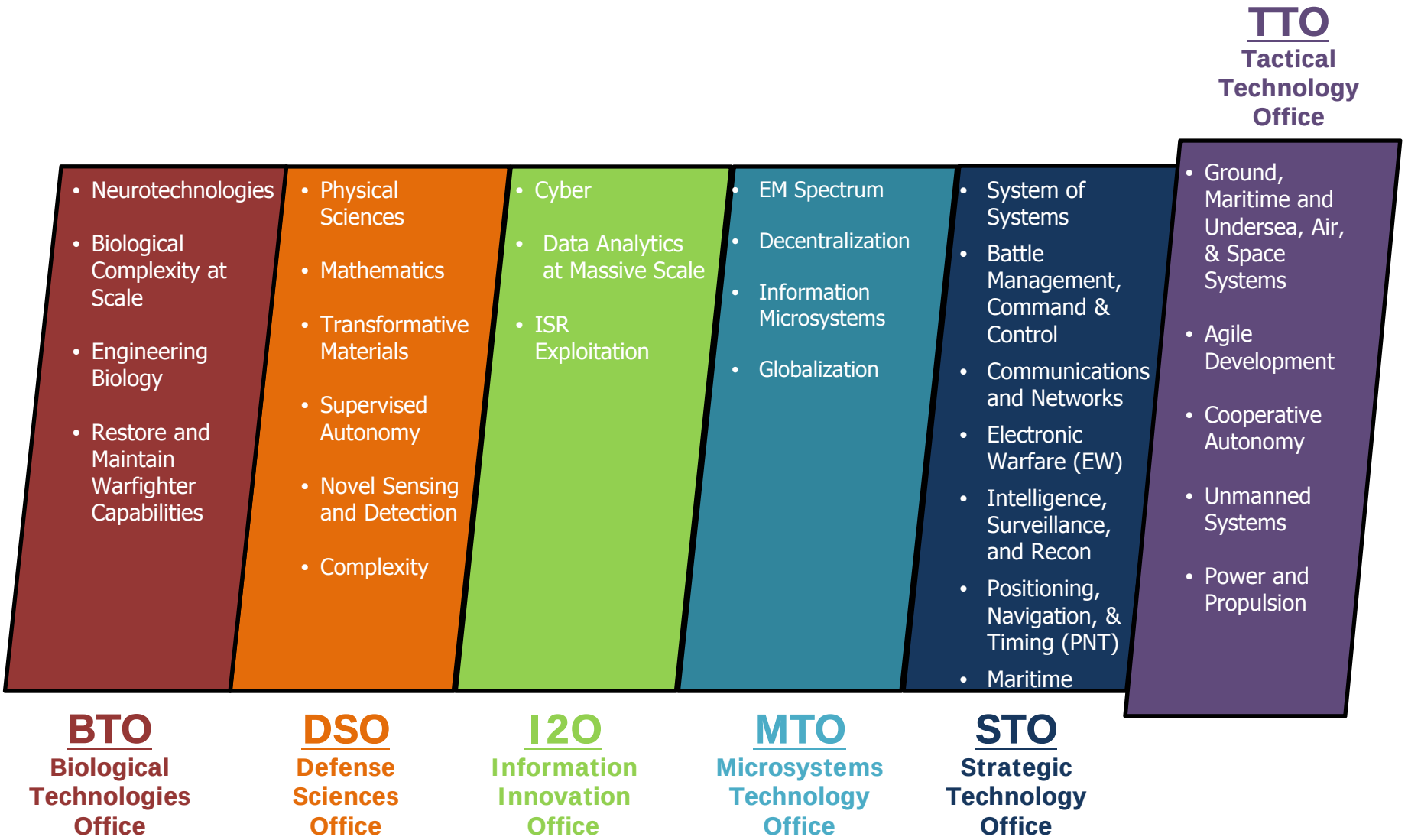
ARPA Established
1958

M16 Assault Rifle
1965

ARPANET
1969

Global Hawk
1998

DARPA Technical Offices



TTO's History

Ground Systems

1967

M16
(Project Agile)

Tank Breaker

Army Tactical
Missile System
(Assault Breaker)

Talon

Boomerang

Netfires

Iron Curtain

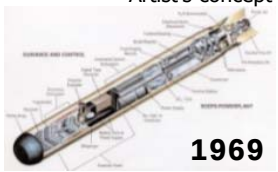
Legged
Squad
Support
System
(LS3)

Artist's concept

Persistent Close
Air Support
(PCAS)

Maritime and Undersea Systems

Artist's concept



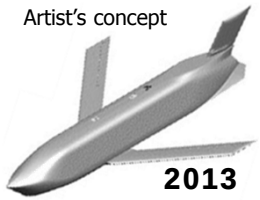
MK 50 Torpedo
Propulsion System

Sea Shadow

Unmanned
Undersea
Vehicle (UUV)

Submarine
Technology
(SUBTECH)

Artist's concept



Long Range
Anti-Ship Missile
(LRASM)

Air Systems

Have Blue

Tacit Blue

X-31

Global Hawk

X-45/46/47

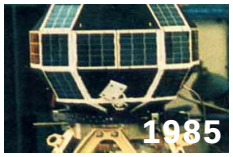
A-160

Damage Tolerant
Controls (DTC)

Artist's concept

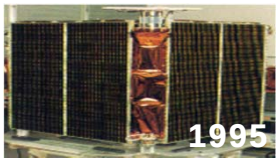
Falcon HTV-2

Space Systems



Global Low Orbiting
Message Relay
(GLOMR)

Pegasus

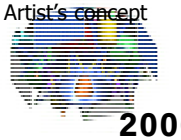


DARPASAT

Taurus

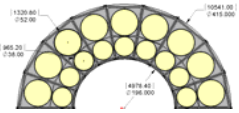
Falcon Small
Launch Vehicle

Artist's concept



MiTEX

Orbital Express (OE)



Membrane Optic
Imager Real-Time
Exploitation
(MOIRE)

Platform and System Focus Areas

Ground Systems

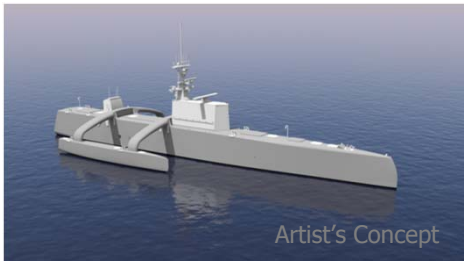
Deployable, mobile capable forces

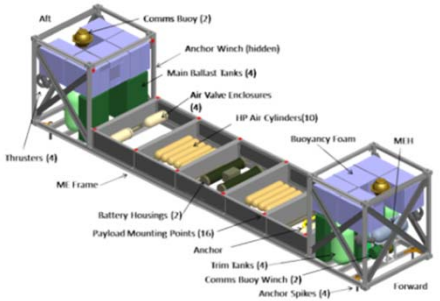
Artist's Concept

Artist's Concept

Maritime and Undersea Systems

Control the sea, influence events on land





Artist's Concept

Air Systems

Extend range and minimize time

Artist's Concept

Artist's Concept

Space Systems

Resilient and flexible

Artist's Concept

Cross-Cutting Themes

Agile development approach, cooperative autonomy, unmanned systems, power and propulsion

Resilience in Space

- Affordable routine access
- Reduce escalating systems cost
- Enhanced survivability, reconstitution and autonomy
- Disaggregation and simplification
- Real-time space domain awareness
- New capabilities

Shaping the Present

Airborne Launch Assist Space Access (ALASA): Affordable, routine and reliable

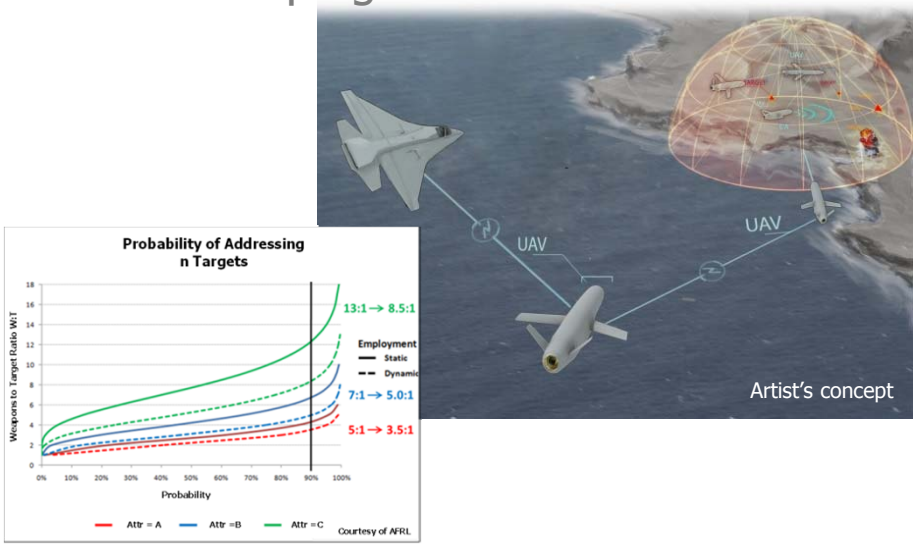
Creating the Future

Hallmark: Real-time space domain awareness, command and control

Developing Advanced and Collaborative Autonomy

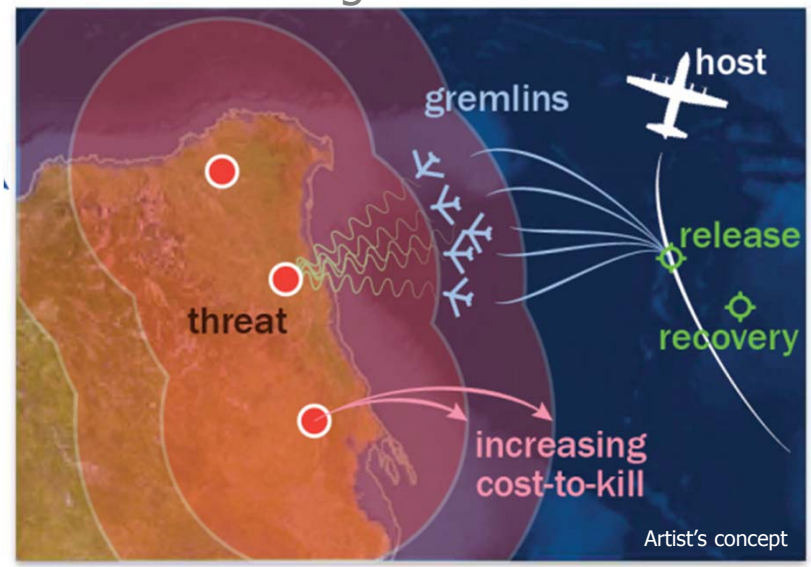
- Coordinated swarming to expand performance envelope – endurance, speed, range, payload, survivability:
  - Autonomy
  - High speed, collaborative precision strike and advanced munitions
- Improved capabilities to enable improved and new missions

Shaping the Present



Collaborative Operations in Denied Environment (CODE): Reduction in salvo size using collaborative dynamic targeting

Creating the Future

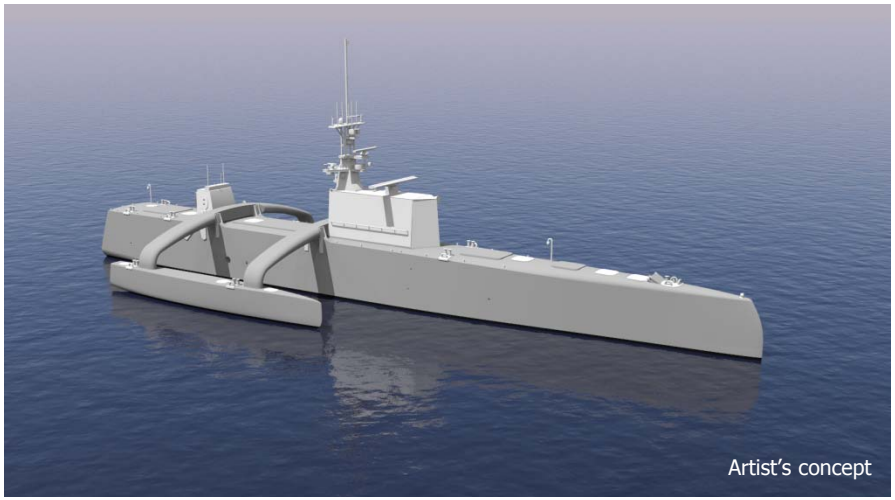


Gremlins: Distributed volleys of recoverable assets

Maritime Capabilities

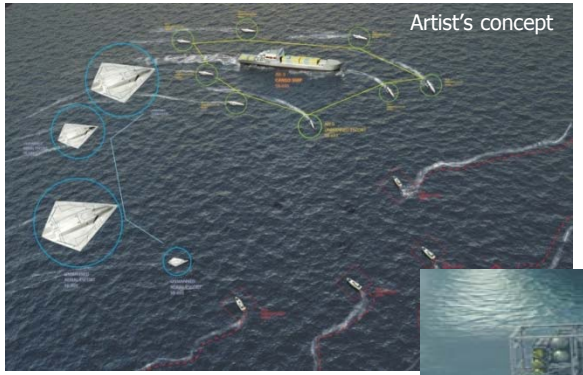
- Survivable and highly distributed systems to deliver effects from long distances
- Ability to perform vital missions without big platforms
- Flip measure/countermeasure cost imbalance in our favor
- Enhanced situational awareness and threat detection
- On the surface or under the sea

Shaping the Present

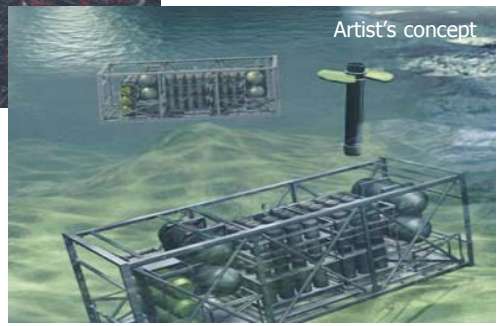


ASW Continuous Trail Unmanned Vessel (ACTUV): Global Hawk for the high seas

Creating the Future



Swarm Challenge: Testing the technologies scale for a swarm of unmanned vehicles

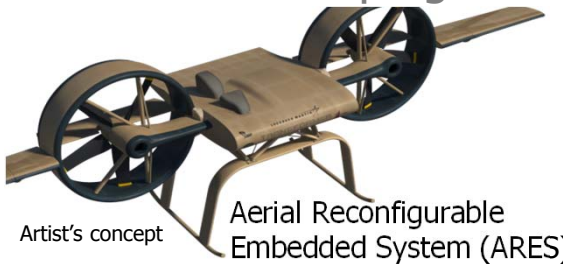


Hydra: Affordable, delivery of unmanned aerial and undersea payloads

Enabling Light, Mobile Forces

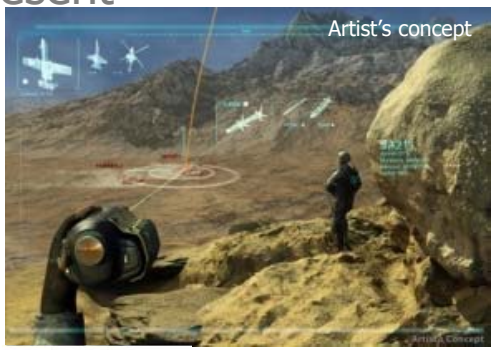
- Extend and enhance the situational awareness of small units
- Enable rifle squads to shape and dominate their battlespace (kinetic and non-kinetic)
- Modular unmanned logistics and transport to the tactical edge
- Improved detection range, accuracy and robustness
- Unit level improvements for all operations phases

Shaping the Present

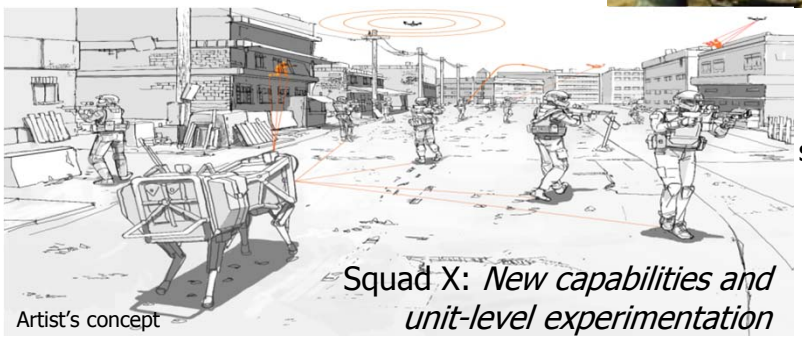


Artist's concept

Aerial Reconfigurable Embedded System (ARES): *Enhance the effectiveness of small-units*



Artist's concept



Artist's concept

Squad X: *New capabilities and unit-level experimentation*

Persistent Close Air Support (PCAS): Shared real-time situational awareness for rapid, precise close air support combining ground and air support

Creating the Future

Ground Experimental Vehicle Technologies (GXV-T): Significantly improving mobility without sacrificing survivability

Artist's concept

Artist's concept

Mobile Infantry: Mixed mounted/ dismounted warfighters and semi-autonomous variants of small off-road platforms

Robotics and Autonomy

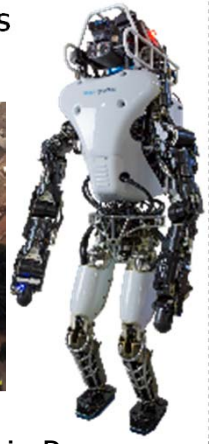
- Improved autonomy, mobility, speed, cost and energy efficiency
- Untethered operation using battery pack for mixed-mission operation
- Onboard perception to support autonomy
- Carrying the load to aid the warfighter
- Rapid commercial growth

Shaping the Present

Artist's concept

Spot (Legged Squad Support System (LS3)):
Smaller, quieter, more reliable next generation robotic platform

DARPA Robotics Challenge (DRC): Human-level mobility and dexterity in austere human environments



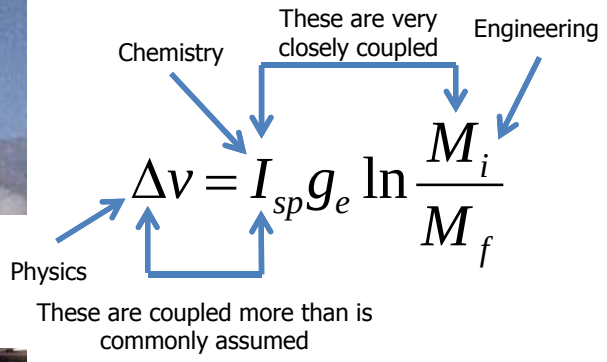
DRC Finals: June 5-6, 2015 in Pomona, California

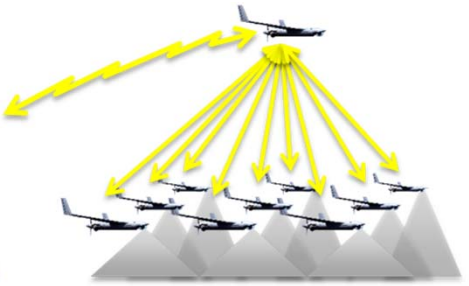
Creating the Future

Aircrew Labor In-cockpit Automation System (ALIAS):
Enable variably reduced onboard crew for existing aircraft

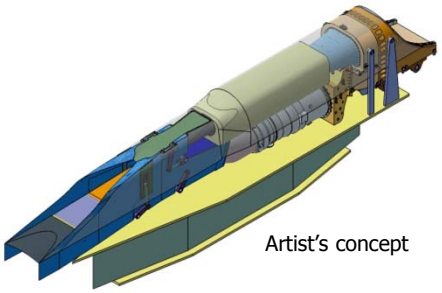
Topics to Consider

- Long-range precision fire
- Advanced rocket propulsion
- Strategic mobility and automation
- Swarm and counter-swarm
- New engines





Artist's concept



Artist's concept

Tactical Technology Office: Office-Wide BAA

Ms. Pamela A. Melroy, Deputy Director

Briefing prepared for TTO Proposers Day

April 29, 2015

Why are we here today?

- We want to make sure that you understand our approach, which includes:
  - The areas we are focusing on and why, so that you can be more effective in what you propose
  - Our process and the realities about the way TTO BAA-15-27 works
- We want to answer your questions:
  - During the sidebars, tell us your ideas for truly revolutionary technologies that are aligned with the program managers' vision for their programs
  - Tell us your thoughts on how we can tap into new ideas that can strengthen our existing programs
- The interchange of ideas between DARPA and industry has always been at the heart of TTO's approach to developing revolutionary technologies:
  - Many programs have started as seedlings from BAA submissions

Our Engine is Made Up of Our PMs' Visions

- PMs are the ones who execute seedlings and programs:
  - Office director and deputy director can help you locate the right PM

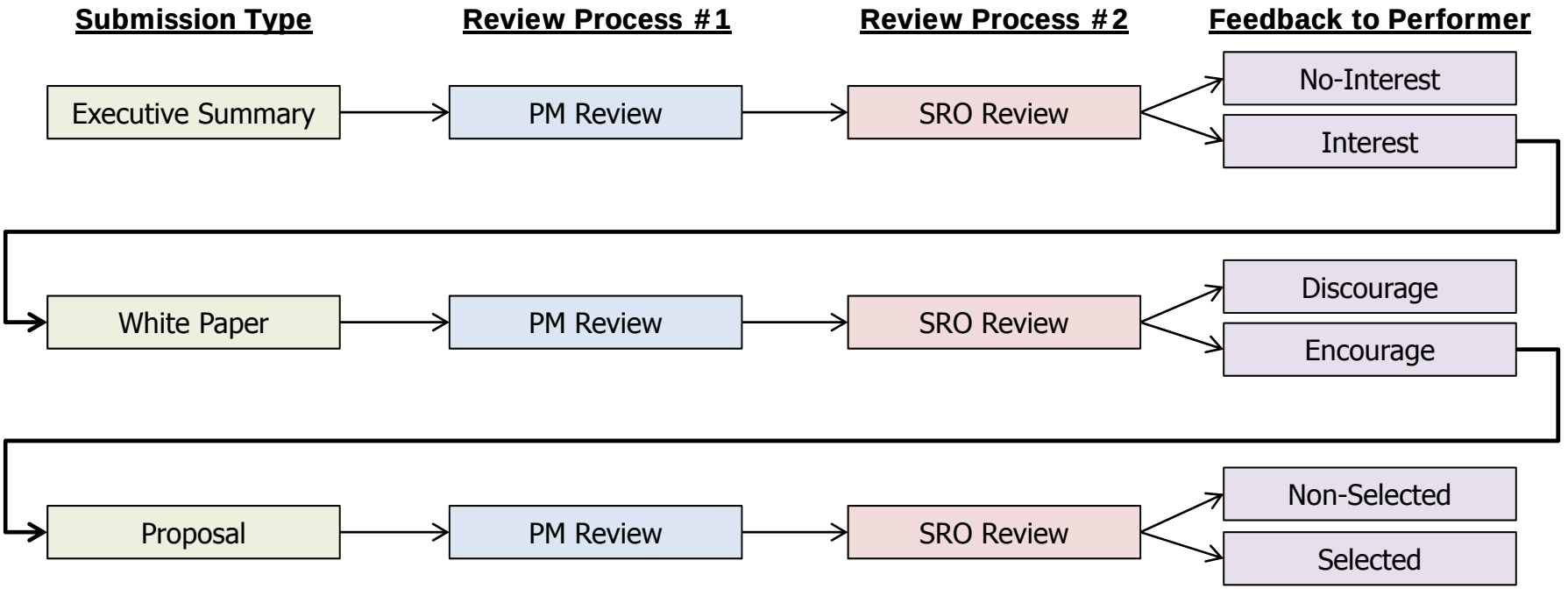
- You may have a good idea, but if it's not aligned with someone's interest area, then it won't happen

- Feedback for executive summaries and white papers can steer you in the right direction before submitting a proposal

How does it work?

- One (1) year-long BAA:
  - Designated BAA coordinator and email address
  - Does not supersede program BAAs

- Executive summaries, white papers, and proposals



How to submit?

- DARPA's BAA website https://baa.darpa.mil
  - NEW as of September 2014 – TFIMS is no longer active
  - NEW – There is no longer a separate deadline for executive summaries, white papers, and proposals
  - Visit the website to complete the two-step registration process
  - First time submitters will need to register for an extranet account (https://baa-registration.darpa.mil/):
    - Wait for two separate e-mails containing a username and temporary password
    - After accessing the Extranet, create an account for the DARPA BAA website via the "Register your Organization" link along the left side of the homepage
    - View submission instructions; all submissions must be submitted as zip files (.zip or .zipx) and be no larger than 50 MB
  - If an account has already been created it may be reused

- Proposers requesting grants or cooperative agreements may submit proposals through one of the following methods:
  - (1) Hard copy mailed directly to DARPA
  - (2) Electronic upload at http://www.grants.gov/applicants/apply-for-grants.html.

Classified Submissions

- Prior to sending any classified submissions, performers must provide advance notification to the BAA coordinator via DARPA-BAA-15-27@darpa.mil
- Proposers choosing to submit classified executive summaries, white papers or proposals from other classified sources must first receive permission from the respective Original Classification Authority in order to use their information in replying to this BAA
  - Applicable classification guide(s) should also be submitted to ensure the proposal is protected at the appropriate classification level
- Classified submissions shall be appropriately and conspicuously marked with the proposed classification level and declassification date. Before transmitting the material, contact DARPA CDR (C/S/TS), SAPCO (SAP) or Special Security Office (SCI)
  - **Confidential and Secret Collateral Information:** Classified information at the Confidential and Secret level may be submitted via ONE of the two following methods:
    - Hand-carried by an appropriately cleared and authorized courier to the DARPA CDR
    - Mailed via appropriate U.S. Postal Service methods (e.g., (USPS) Registered Mail or USPS Express Mail)
  - **Top Secret materials:** Top Secret information should be hand carried by an appropriately cleared and authorized courier to the DARPA Classified Document Registry
  - **Special Access Program (SAP) Information:** SAP information must be transmitted via approved methods
  - **Sensitive Compartmented Information (SCI):** SCI must be transmitted via approved methods

Things to Keep in Mind (1 of 3)

- No-Interest/Discourage means:
  - In the form you submitted, we are not interested in your idea because:
    - The submission does not present an approach to developing technology that is aligned with the DARPA/TTO focus areas and interests
    - The submission is not important to TTO's areas of responsibility as outlined in the BAA
    - The submission is not suitably structured to produce a TTO systems-level demonstration or product
    - The submission does not substantiate a revolutionary military capability within the TTO portfolio
    - The proposed approach does not clearly identify current limitations that would be overcome
    - The submission does not identify barriers to implementing new operational concepts and postulate solutions
    - The submission does not convey technology significantly beyond the state of the art
    - The submitted work does not provide sufficient information to assess the technical performance claims
  - It does NOT mean that you cannot submit a full proposal... BUT chances of success are extremely slim

Things to Keep in Mind (2 of 3)

- Common misunderstandings:
  - You can submit any time in the period, not just at the due date
  - Make sure it is relevant to TTO – your idea may be more relevant for another DARPA technical office
  - Please explain how your technology works and how it enables a new capability
  - We will not be developing your idea – you will have to do the work
    - Are you proposing a study? A demo? Tell us what you would deliver and how you would deliver it
  - Do your homework – how is the task accomplished today and how much would your technology compare in cost, performance and operations?
  - Not all this detail is needed in an Executive Summary, but you should have considered all of it when submitting

Things to Keep in Mind (3 of 3)

- Interest/Encourage means:
  - We find your idea interesting and we would like to know more
  - It does NOT mean that you are funded or that a full proposal will be accepted

- Funding and seedling length expectation:
  - Intent is to fund seedlings at <$1M
  - Typically, seedlings are 12-18 months in duration unless there is valid justification for a longer effort
  - Efforts larger than seedlings are likely to be handled as a program – options or through a program BAA
  - Okay to propose options for a larger follow-on program
    - You may submit a cost proposal with various options (1, 2…n) so that you have a phased approach, but this would only be one volume

Do and Don'ts

- DO read the TTO BAA-15-27 document in its entirety
- DO use the executive summary and white paper process
- DO forward any questions related to the DARPA/TTO BAA-15-27 to DARPA-BAA-15-27@darpa.mil

- Do NOT recirculate proposals rejected from program BAAs
- Do NOT hand-carry paper copies to the DARPA building
- Do NOT email/fax in your executive summary, white paper, or proposal to the TTO BAA-15-27 mailbox
- Do NOT call to check on the status of your submission

Questions?

- Is the feedback in the letters useful?

- How can we improve the process?*

*...please don't ask us to change the Federal Acquisition Regulations!

TTO Proposers Day 2015

Mr. John Kamp, STO Program Manager

Briefing prepared for TTO Proposers Day

April 29, 2015

Current TTO Program

Blue Wolf

- Develop and demonstrate integrated underwater vehicle prototypes

Artist's Concept

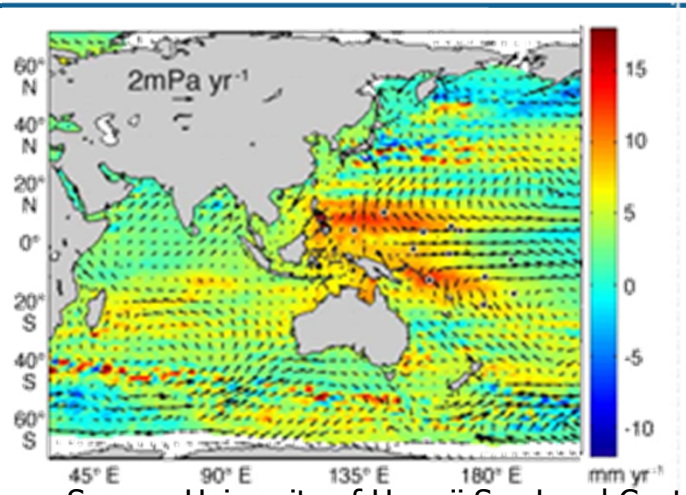
- Capable of operating at speed-range combinations previously unachievable in fixed-size platforms
  - Dynamic lift/drag reduction
  - Hybrid energy systems
  - Retain traditional volume and weight fractions for payloads and electronics

- Collaboration with Navy
  - Reference vehicle testing designed to lead to integrated system
  - Certification
  - At-sea launch and control demonstrations

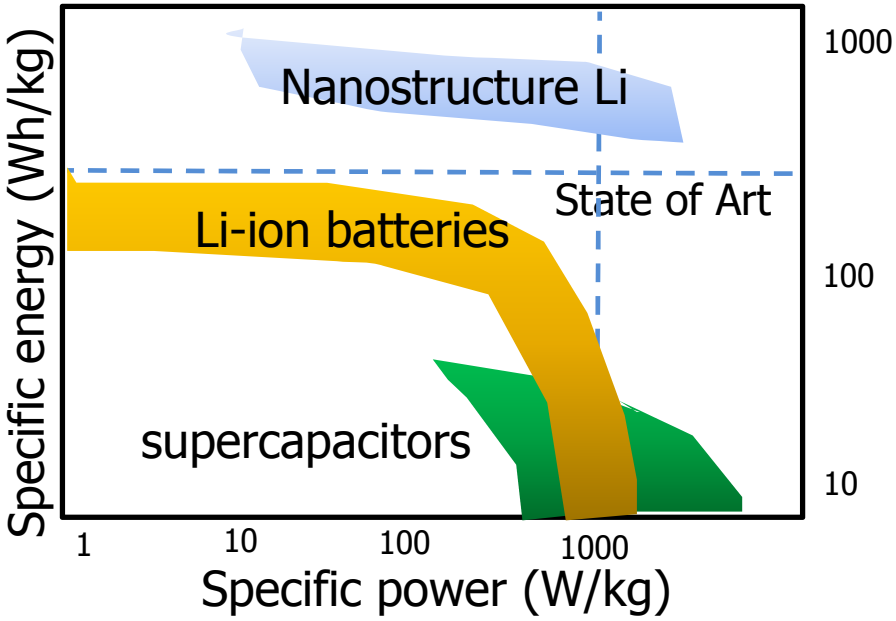
Interest Areas

- Autonomous maritime systems for littoral operations
  - Work with environment
  - Energy harvesting
  - Novel hybrid systems
  - Improved range, endurance

- Innovative manufacturing methods for undersea systems
  - Novel energy systems exploiting nanofabrication methods
  - Additive manufacturing to improve reliability and reduced cost of pressure-tolerance
  - Lightweight and strong structural materials exploiting novel manufacturing processes
  - Novel undersea structures
    - Expanding structures



Source: University of Hawaii Sea Level Center



TTO Proposers Day 2015

Mr. Scott Littlefield, TTO Program Manager

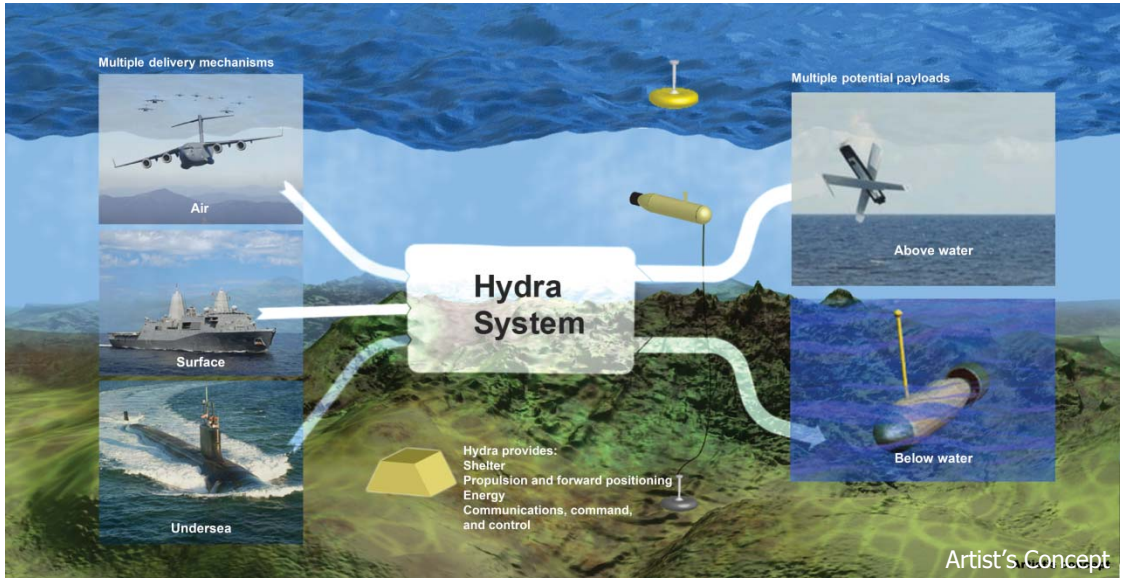
Briefing prepared for TTO Proposers Day

April 29, 2015

Current TTO Programs

Anti-Submarine Warfare (ASW) Continuous Trail Unmanned Vessel (ACTUV) seeks to develop a large unmanned surface vessel with ocean-spanning range and a high level of autonomy. Originally designed for an ASW track and trail mission, other missions are being considered in a cooperative program with the Office of Naval Research (ONR).

Hydra seeks to create a force multiplier that would enable rapid, scalable and cost-effective deployment of capabilities much faster and more cost-effectively wherever needed.



Theme: affordable maritime payload capacity

Interest Areas

Enhancements to ACTUV:

- EO/IR detection and classification of surface vessels
- New payloads
- Autonomous detection of marine mammals

Enhancements to Hydra:

- Energy, communications, new payloads, concepts for deployment and use

Swarm: Integrate magnetic sensors and other sensors on a group of semi-autonomous UAVs launched from small warships to provide a new ASW search capability

- Key technical areas include: aircraft, sensor integration; intelligent search behavior; resilient communication architecture; reduced manning

Artist's Concept

TTO Proposers Day 2015

Dr. Chris Warren, TTO Program Manager

Briefing prepared for TTO Proposers Day

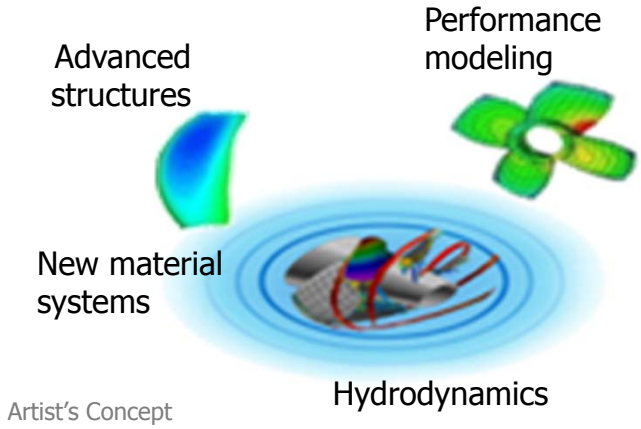
April 29, 2015

Current TTO Program

Hybrid Multi-Material Rotor Full Scale Demonstration Program (HyDem)

- Goal: Dramatically improve U.S. Navy submarine superiority by applying breakthroughs in materials, material system technologies, and multi-disciplinary design methods to a Virginia-class submarine rotor, a critical component in submarine performance

- Approach:
  - Design, manufacture, and supply the Navy with a novel component for integration into a new construction Virginia Class Submarine
  - The Navy would evaluate this component in sea trials, and—at the Navy's discretion—integrate into the future fleet



Artist's Concept

Interest Areas

- Maritime technologies that enable ***significant*** performance increases
- Cost-advantageous technologies to shifts cost asymmetry in favor of the United States
- New, novel, cost-effective platform approaches to today's missions
- Non-lethal approaches to projecting power in the maritime domain

- Underwater platforms and platform technologies
- Maritime propulsion technologies
- At sea energy harvesting, scavenging, management
- Advanced hydrodynamic concepts
- Cross-domain platforms (water-air, water-ground, space-water, etc.)

TTO Proposers Day 2015

Mr. Jerome Dunn, TTO Program Manager

Briefing prepared for TTO Proposers Day

April 29, 2015

Current TTO Programs

- Current Programs:
  - Extreme Accuracy Tasked Ordnance (**EXACTO**)
  - Multi-Azimuth Defense Fast Intercept Round Engagement System (**MAD-FIRES**)


Artist's Concept

- With the help of DARPA's Adaptive Execution Office (AEO), EXACTO demonstrated accurate engagement of on-the-move targets using a .50-caliber round

- MAD-FIRES is starting this year with exciting implications for all medium-caliber missions
  - Gunships
  - Counter-rocket and mortar
  - Counter-UAV and Missiles
  - Counter-swarming fast-attack craft
  - Ground-to-ground combat


Artist's Concept

Interest Areas

- Kinetic defeat of threats to U.S. platforms
  - Near-shore threats (e.g. small boats)
  - UAV and cruise missile threats
  - Wider applications:
    - Army—Counter-rocket, -artillery, -mortar and -UAS
    - AFSOC—AC-130 gunship

- Multi-Domain Unmanned Systems (UxSes)
  - Multi-domain transport and insertion technologies
  - Novel energy harvesting and approaches to power and propulsion
  - Long-range navigation and long duration station keeping
  - Reliable launch and recovery
  - Non-traditional ISR/forensic sensors (e.g. lab on a chip)
  - Real-time, low-power data fusion, long-duration change detection
  - Ad-hoc, self-forming networks

Maritime and Undersea Panel Q&A

Mr. Jerome Dunn

Mr. John Kamp

Mr. Scott Littlefield

Dr. Christopher Warren

TTO Proposers Day 2015

Dr. Kevin Massey, TTO Program Manager

Briefing prepared for TTO Proposers Day

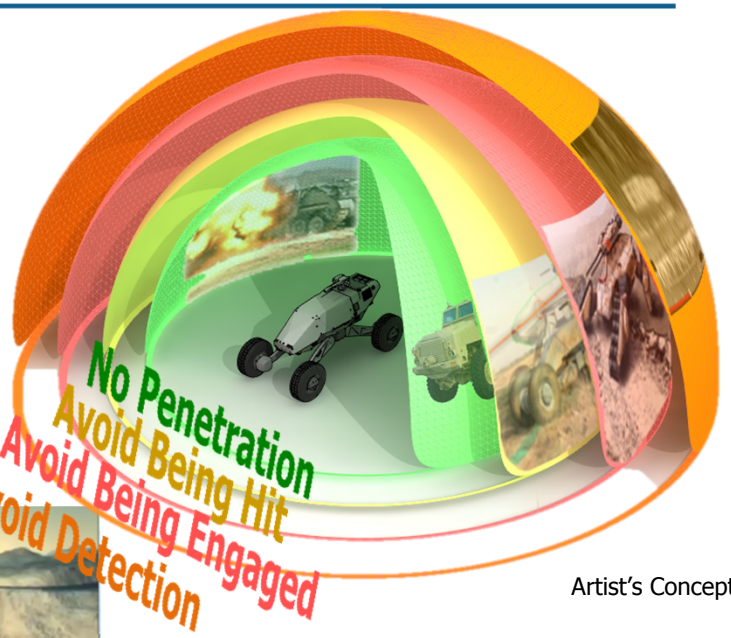
April 29, 2015

Current TTO Program

Ground X-Vehicle Technologies (GXV-T)

GXV-T Program Objective

Develop new generation of ground combat vehicle technologies that significantly improve expeditionary mobility without sacrificing survivability



Artist's Concept


Artist's Concept

Artist's Concept

GXV-T Program

- X-Plane paradigm
  - Technology push (not transition pull)
- Not replacing combat vehicles/IFVs
  - Transforming/augmenting their designs
- Aims to break the 'More Armor' paradigm

Artist's Concept

Interest Areas

- **Advanced Ground Vehicles**
  - Advanced mobility
  - Vehicle agility
  - Crew augmentation
  - Reduced vehicle signatures
  - Vehicle concepts

- **Quiet Unmanned Air Systems**
  - Novel quiet propulsion systems
  - Long endurance and long range
  - Autonomous terrain-following systems

TTO Proposers Day 2015

Dr. Mark Micire, DSO Program Manager

Briefing prepared for TTO Proposers Day

April 29, 2015

Current TTO Program

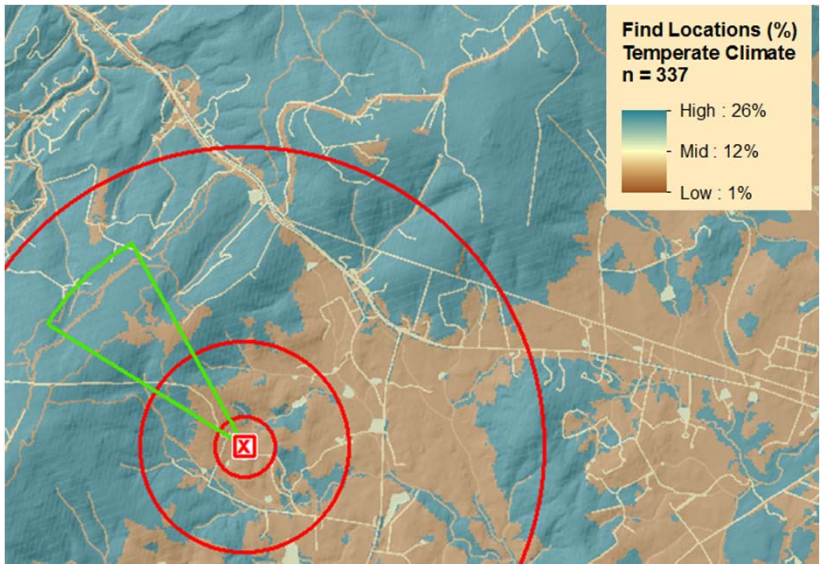
Robotics Fast Track (RFT)

- Engage a growing and dynamic demographic of talent in robotics
- Capture robotics projects with focus on shorter time frames, low cost, and results in less than 12 months
- Extend the existing performer base to include non-standard, cutting-edge organizations and individuals throughout the robotics community
- Demonstrate the ability for robotics projects to be performed at an asymmetric advantage in time, cost and potential benefit

Interest Area

Search with a Virtual Swarm (SVS)

- **Given:** Air robots, ground robots, target's last known location
  - Types of air robots: Raven, Scan Eagle
  - Types of ground robots: RoboGator, Polaris with autonomy package, …
  - Deployment location: Same for air and ground robots
- **Find:** Lost persons
  - The persons move (wandering around) intermittently
- Multiple runs, progressing from easier to harder conditions
  - Number of lost persons ($1 \leq N_P \leq 5$)
  - Number of air robots ($1 \leq N_A \leq 1{,}000$)
  - Number of ground robots ($1 \leq N_G \leq 100$)
  - Terrain: Desert, woodland, mountain, jungle, urban
  - Area: 10x10 km, 15x15 km, 20x20 km, 25x25 km



Interest Areas

- Swarm technology
  - What are the bottlenecks to scaling up to robot swarms to n=100 or n=1,000?
    - Includes communications, coordination, shared knowledge representation
  - Mathematics/formal methods
    - Forward problem: Given rules, determine swarm behavior
    - Inverse problem: Given desired swarm behavior, find rules
  - Prototype swarm system

- Human-robot interaction
  - Models of human users for robots, Models of robots for users
  - Science of interaction, with methods that generalize over tasks and users, and work in dynamic uncertain situations

TTO Proposers Day 2015

MAJ Christopher Orlowski, PhD, TTO Program Manager

Briefing prepared for TTO Proposers Day

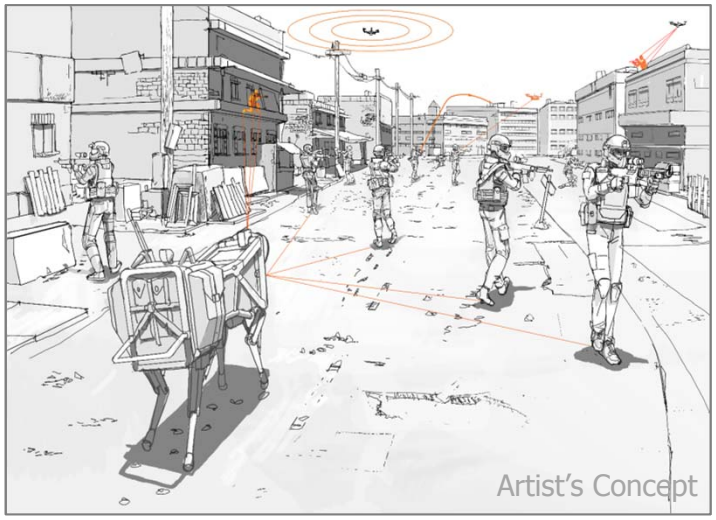
April 29, 2015

Current TTO Programs

- **Legged Squad Support System (LS3):** Seeks to demonstrate that a highly mobile, semi-autonomous legged robot can carry 400 lbs of a squad's load, follow squad members through rugged terrain and interact with troops in a natural way

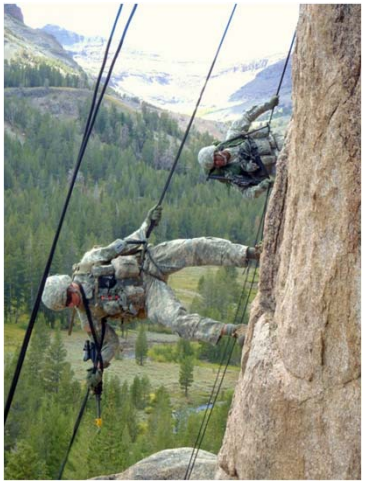
- **Squad X Infrastructure:** Seeks to reduce risk for the development of an integrated, organic system to extend the squad's situational awareness and enable more effective domination of the battlespace

- **Squad X Core Technologies:** Seeks to deliver organic capabilities to the rifle squad that would enable them to shape their battlespace and deliver precision effects to dominate their battlespace



Interest Areas

- Collaborative autonomy for ground combat applications
  - Unmanned systems capable of conducting squad/section/platoon collective tasks
  - Man-machine teaming applications to improve force effectiveness
- Solutions for unique, challenging, and complex environments
  - Arctic
  - Forest and jungle
  - Amphibious and subterranean/superterranean
- Increasing the combat power of light units
  - Firepower
    - Precision engagement capabilities
    - Non-kinetic/non-lethal engagement capabilities
  - Protection
    - Warfighter signature reduction
    - Countermeasures for emerging and future threats
  - Mobility
    - Capabilities that require low-size, -weight, and -power
    - Increasing warfighter access to terrain in three dimensions
- User interfaces that enhance the task performance and reduce the cognitive burden of warfighters



Ground Panel Q&A

Dr. Kevin Massey
Dr. Mark Micire
MAJ Christopher Orlowski, PhD

TTO Proposers Day 2015

Dr. Ashish Bagai, TTO Program Manager

Briefing prepared for TTO Proposers Day

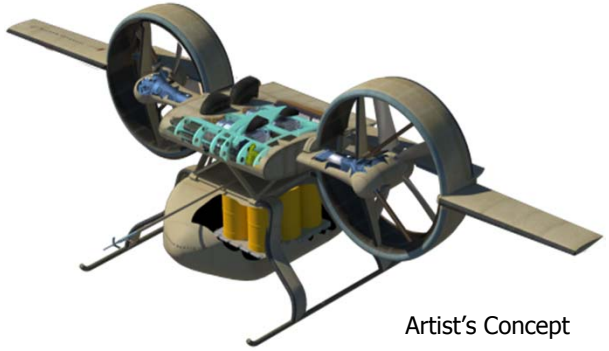
April 29, 2015

Current TTO Programs

- Vertical Takeoff and Landing X-Plane (VTOL X-Plane)
  - Diverse VTOL technology push to enable capabilities
  - Advance state of the art VTOL design tools

VTOL X-Plane

- Aerial Reconfigurable Embedded System (ARES)
  - Technological advancement of VTOL unmanned air system (UAS) with modular multi-mission capability



ARES

- Adaptive Robotic Landing Gear (RLG) Seedling
  - Development and testing of robotic landing gear on small unmanned air vehicle

Adaptive Robotic Landing Gear

Interest Areas

- Technologies relevant to vertical flight
  - Aeromechanics, flight controls, guidance-navigation-control (GN&C)
- Manned/unmanned systems + teaming
- Propulsion and transmission systems
- Configurations and systems integration
- Novel capabilities and missions
- Applied and fundamental sciences

TTO Proposers Day 2015

Dr. Peter Erbland, TTO Program Manager

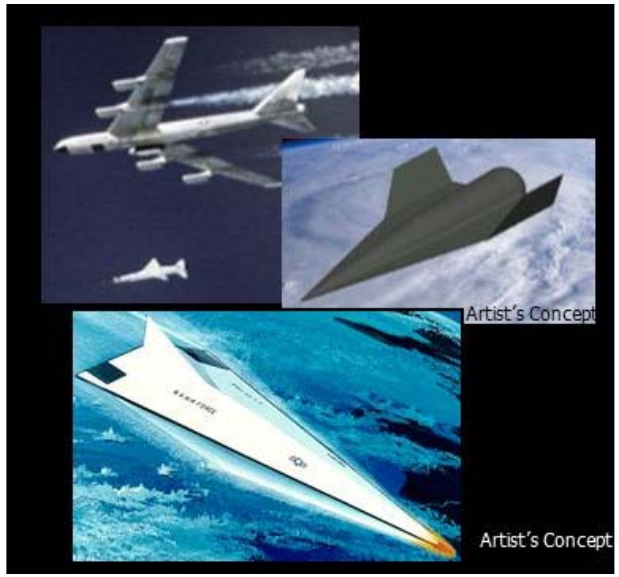
Briefing prepared for TTO Proposers Day

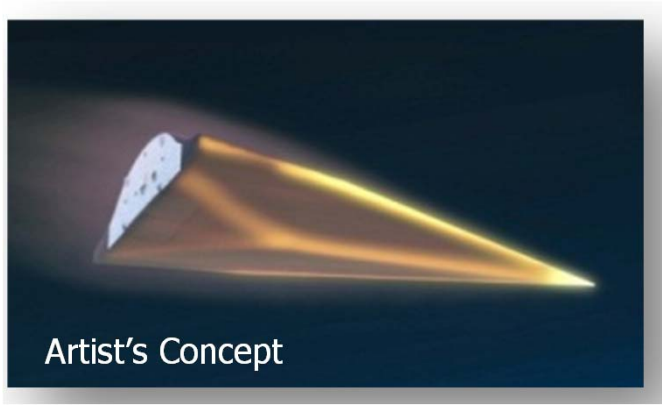
April 29, 2015

Current TTO Program

Tactical Boost Glide (TBG)

- Objective: Demonstrate technologies to enable future air-launched, tactical-range hypersonic boost glide systems, including flight demonstration

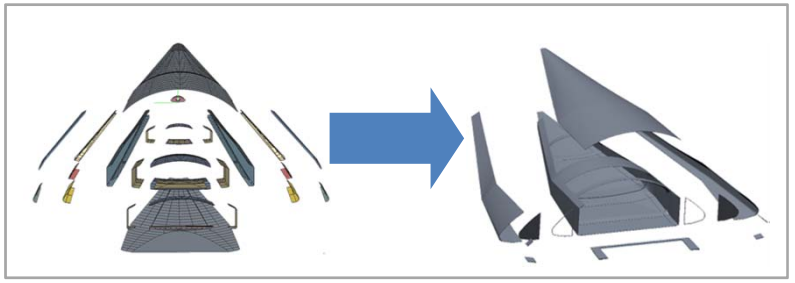




Interest Areas

Hot Structures for Hypersonic Vehicles

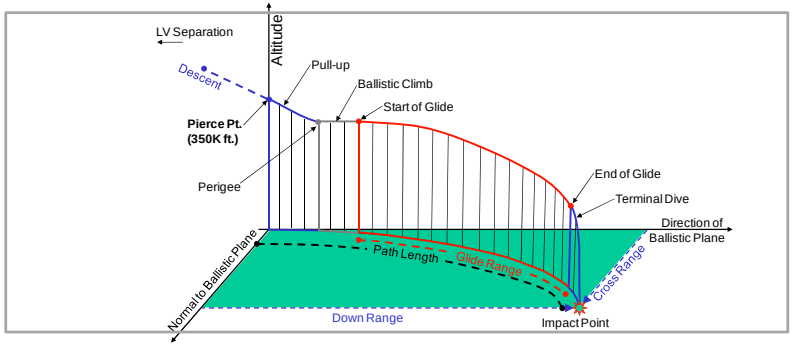
- Demonstrate material maturity, optimal structural design and affordable manufacturing approaches for hypersonic systems
- Benefits – robust design with higher margins and reduced time/cost to manufacture



Stable properties
Reduced part count

Guidance, Navigation, and Control (GNC)

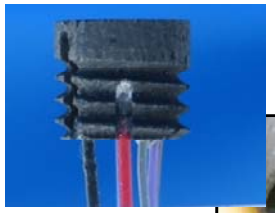
- Robust adaptive guidance and control
- Real-time, highly constrained multi-phase optimal trajectory generation
- Benefits – expanded flight envelope, increased control, ability to optimize system and mission performance during flight, reduced mission planning times



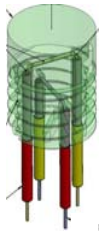
Real time adaptation and optimization

Advanced Instrumentation

- Instrumentation approaches to address critical deficiencies, especially aeroshell thermal and recession, and vehicle "air data" measurements
- Benefits – enable collection of critical data for aeroshell thermal performance assessment and for adaptive GNC and trajectory optimization capability



Flush Air Data Port
Courtesy HTG
Goettingen



C/C Thermocouple Plug

TTO Proposers Day 2015

Mr. Mark Gustafson, TTO Program Manager

Briefing prepared for TTO Proposers Day

April 29, 2015

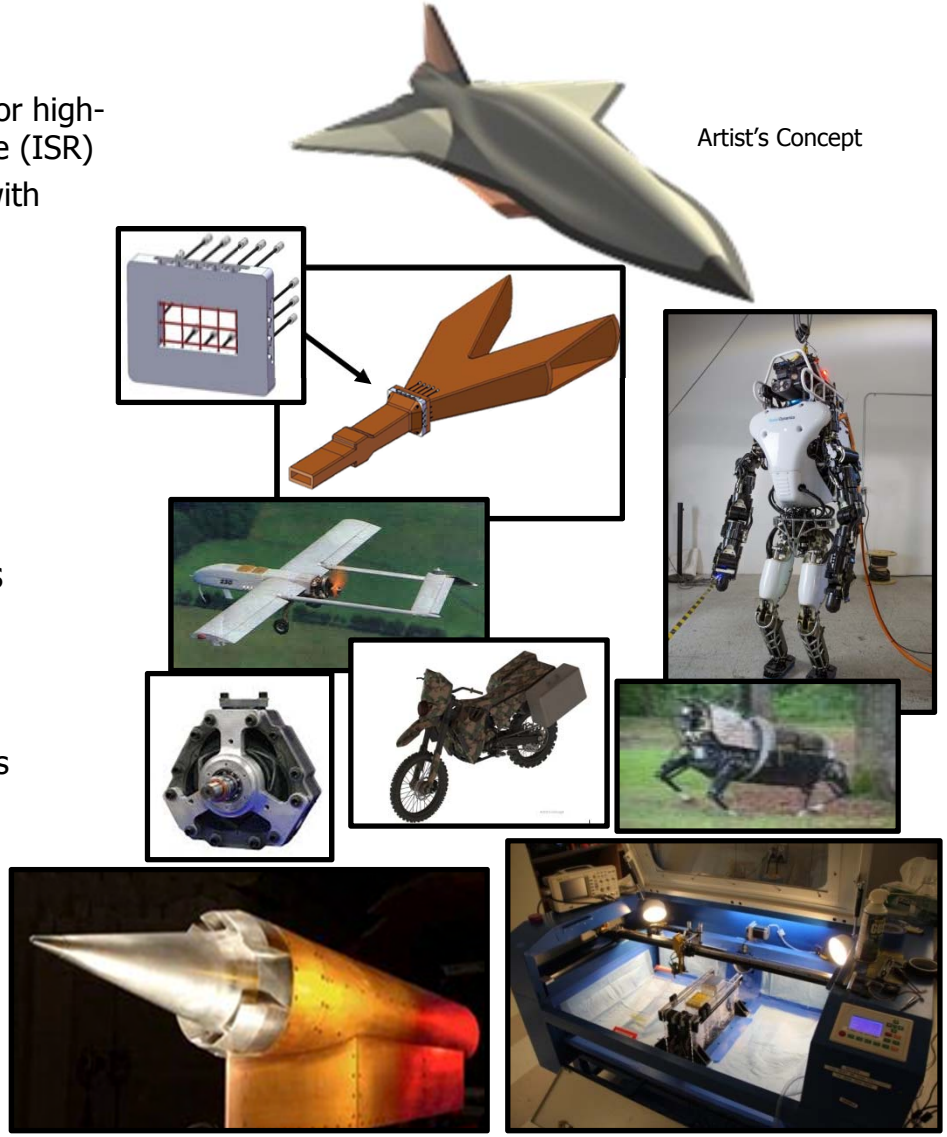
Current TTO Program

Hypersonic Air-breathing Weapon Concept (HAWC)

- Objectives: Transformational changes in responsive, long-range strike capabilities against time-critical or heavily defended targets. Joint DARPA/Air Force (AFRL) program
  - Advanced air vehicle configurations capable of efficient hypersonic flight
  - Hydrocarbon scramjet-powered propulsion to enable sustained hypersonic cruise
  - Thermal management approaches designed for high-temperature cruise
  - Affordable system designs and manufacturing approaches

Interest Areas

- Innovative Propulsion Concepts
  - Mach 0-to-7 aircraft capable of two-stage-to-orbit or high-speed intelligence, surveillance and reconnaissance (ISR)
  - Rotating detonation engine or turbine integrated with dual-mode ramjet
- Non-Intrusive Diagnostics
  - Sensors for high-temperature applications
  - Internal flow diagnostics
  - Air-data systems
- Innovative Internal Combustion Engine Concepts
  - Compact
  - Specific power > 2hp/lb
  - Specific fuel consumption of < 0.30 pph/hp
  - Unmanned Aerial Vehicles and robotics applications
- Additive Manufacturing Demonstrations
  - Lightweight superalloys or composite materials
  - Ram/Scramjet powered vehicle configurations



TTO Proposers Day 2015

Mr. Jean-Charles (JC) Ledé, TTO Program Manager

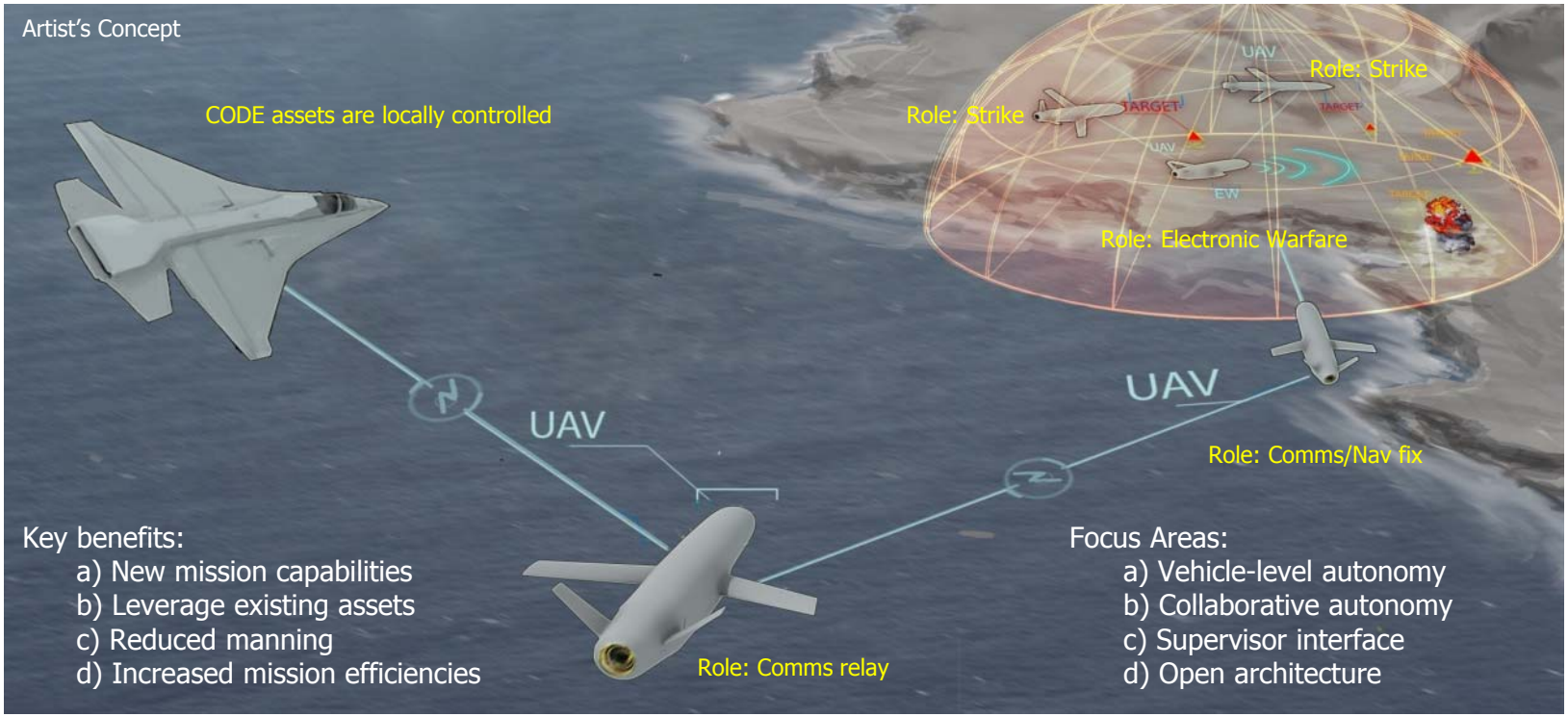
Briefing prepared for TTO Proposers Day

April 29, 2015

Current TTO Program

Collaborative Operations in Denied Environment (CODE)

Develop and demonstrate algorithms that would expand the mission capabilities of legacy assets through autonomy and collaborative behaviors



Interest Areas

- Autonomy for aerial vehicles
  - Improved perception
  - Collaboration among heterogeneous vehicles
- Counter-UAS
  - Detect, identify, neutralize
- Advanced flight controls
  - Fault-tolerant/-adaptive
  - Multi-vehicles in close formation or connected
- Advanced vehicle configurations or critical airplane subsystems that improve mission performance by an order of magnitude
- Counter-swarm
  - Low-cost, robust neutralization mechanisms
- Precision strike in urban terrain
  - 3D targeting
  - Highly maneuverable munitions
- Any ideas to reduce the time to deploy new DoD capabilities by ~2 orders of magnitude

TTO Proposers Day 2015

Dr. Daniel Patt, TTO Program Manager

Briefing prepared for TTO Proposers Day

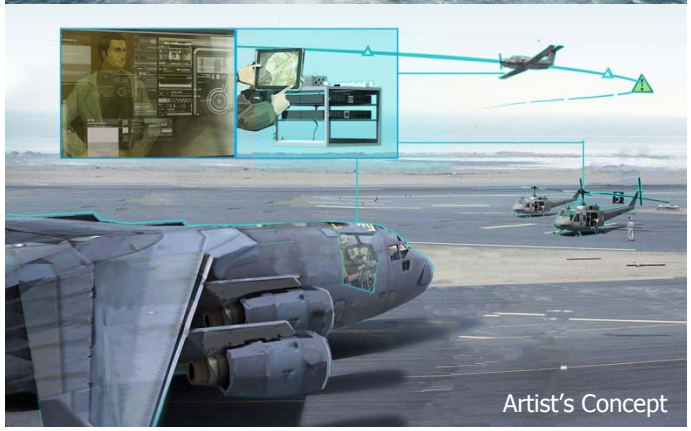
April 29, 2015

Current TTO Programs

- Persistent Close Air Support (**PCAS**)
- Focus on technologies/architectures to enhance air-ground coordination
- Currently in final testing phases
- Elements transitioning to Services

- **Tern**: Joint DARPA/Navy program focusing on tech demo of medium-altitude long-endurance (MALE) unmanned aircraft capability, operable from small ships
- Currently in Phase 2

- Aircrew Labor In-Cockpit Automation System (**ALIAS**)
- Exploring human/automation synergy
- Envision addition of high levels of automation into existing aircraft to enable operation with reduced onboard crew



Interest Areas

- Focus on novel systems architectures that can enable fundamentally different ways of approaching problems, with high potential for game-changing impact

- Technology elements
  - Air vehicles
  - Robotics
  - Human interfaces
  - Collaboration toolsets
  - Flight control
  - Verification
  - Manufacturing
  - Adaptive systems
  - Perception systems
  - Fault tolerance

Air Panel Q&A

Dr. Ashish Bagai

Dr. Peter Erbland

Mr. Mark Gustafson

Mr. Jean-Charles Ledé

Dr. Daniel Patt

TTO Proposers Day 2015

Mr. Mitchell Burnside Clapp, TTO Program Manager

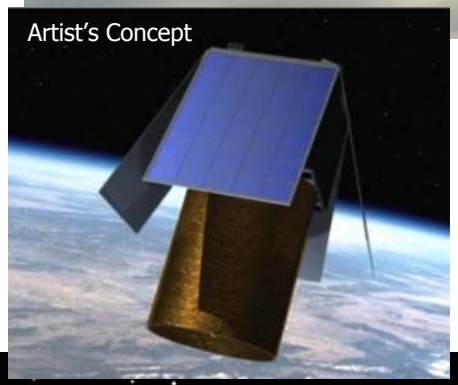
Briefing prepared for TTO Proposers Day

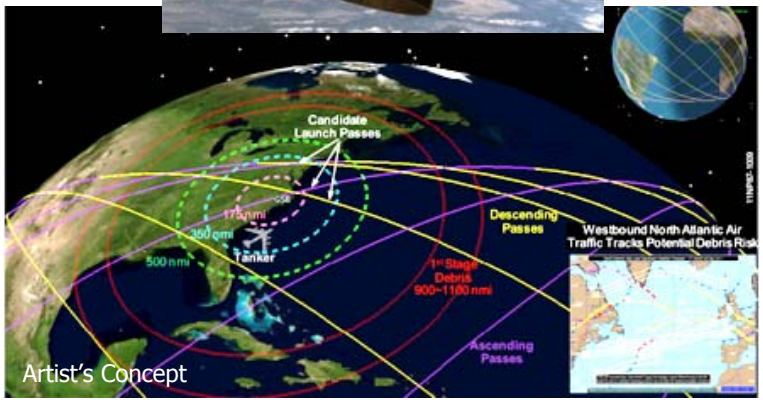
April 29, 2015

Current TTO Programs

Airborne Launch Assist Space Access (ALASA)

- Launch 100-lb satellites into space from unmodified aircraft
- Seeking $1M or less per flight
- 24 hours from call-up to orbit
- Flexible orbital selection
- Resilient to loss of airfield
- Use of novel propellants

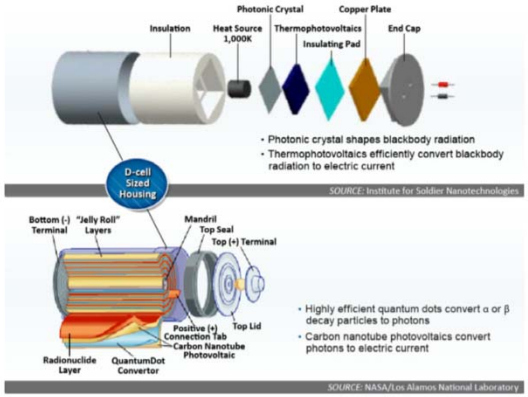




Interest Areas

- Inertial control of flight vehicles
  - Use modern gyroscopes to stabilize unstable systems
  - Provide attitude control, possibly electrical power via flywheel batteries
  - Aircraft and rocket applications possible

- Conversion of radioisotope heat to electricity
  - Enable long-duration, low-power missions
  - Maritime, space, ground applications
  - Short of the threshold of criticality (<10kW)



- Dense rocket propellants
  - Propellant density matters:
    - Structural mass fractions of dense propellant tanks can be as low as 1 percent
    - Engine design is affected too—pumps move gallons, not pounds
  - Modern structural materials and manufacturing techniques, combined with propellants with density greater than water, offer substantial promise
  - This area is almost completely unexplored

TTO Proposers Day 2015

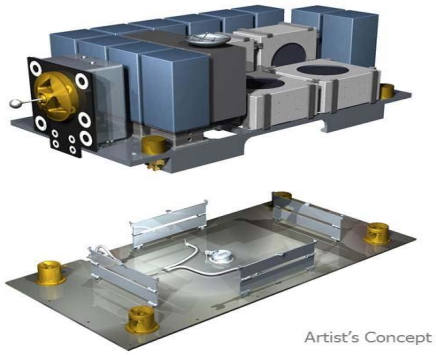
Lt. Col Larry Gunn, TTO Program Manager

Briefing prepared for TTO Proposers Day

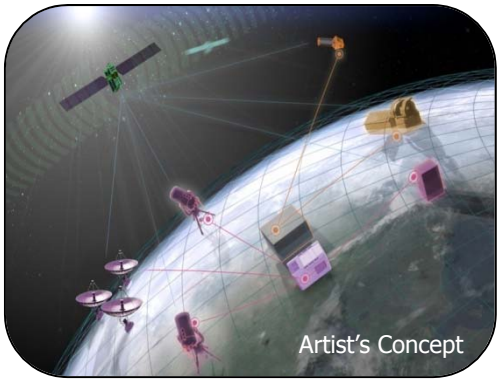
April 29, 2015

Current TTO Programs

- **Phoenix Payload Orbital Delivery (POD) System**
  - Seeks to develop "FedEx® to GEO" capability leveraging frequent commercial satellite launches to deliver faster and lower-cost delivery of payloads to geosynchronous Earth orbit (GEO)
  - Publicly released ICD 10 Nov 2014
  - POD transition opportunities


Artist's Concept

- **Orbit Outlook (O2)**
  - Demonstrating amateur, commercial and academic sensor utility with qualification algorithms
  - Entered Phase 2 – focus on algorithms


Artist's Concept

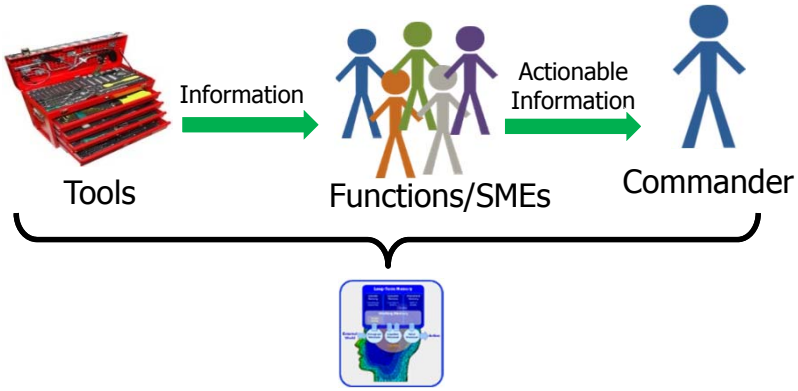
- **Hallmark** seeks to develop R&D test bed for real-time space domain awareness and command and control
  - Producing information and understanding of Space Domain data that enables time relevant decisions


Artist's Concept

Interest Areas

- Develop new tools to assist Joint Space Operations Center (JSPOC) operators, and commanders' responsibilities for real-time space domain awareness and command and control
  - Decision analysis tools
  - Course of action (COA) generation
  - Explore predictive analysis to better understand the comprehensive operating domain and possible future outcomes

- Information comprehension and communication techniques for awareness
  - Methods to comprehend the real-time space environment as it applies to JSPOC operators' responsibilities and commanders' responsibilities for real-time space domain awareness and command and control using full-spectrum data



Apply Comprehension and Decision Cognitive Analysis

TTO Proposers Day 2015

Dr. Lindsay Millard, TTO Program Manager

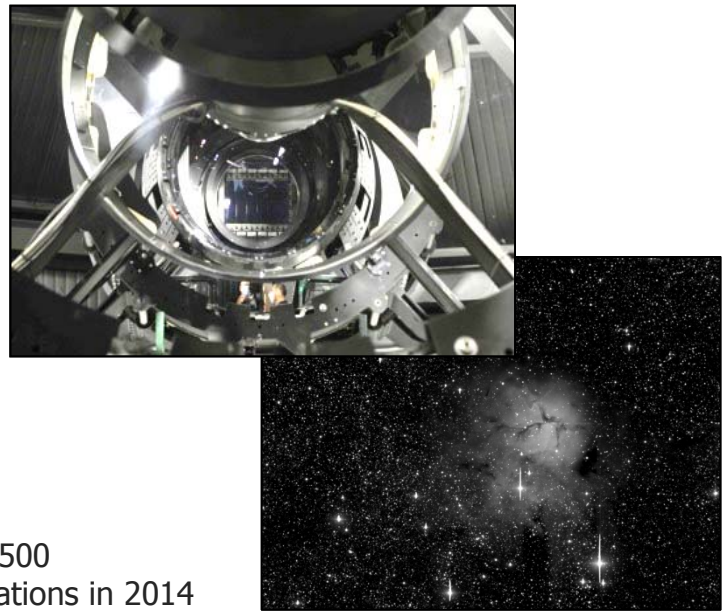
Briefing prepared for TTO Proposers Day

April 29, 2015

Current Programs

Space Surveillance Telescope (SST)

- Currently at White Sands Missile Range in New Mexico
- Offers ground-based capability for rapid, un-cued search, detection and tracking of objects in deep space
- Developing enhanced small-object detection algorithms, advanced wide-field camera, and faster search CONOPS for the DoD space surveillance community
- Searches an area the size of the United States in seconds, can survey ¼ of the GEO region of the sky multiple times in a single night
- Also supports the astronomical community, through the Large Synoptic Space Telescope Consortium. Discovered more than 500 new asteroids and took more than 1.5 million asteroid observations in 2014



Optical Apertures Self-Assembling in Space (OASIS)

Goals:

- Enable construction of very large apertures in orbit, from smaller modular components
- Sidestep launch size and weight limitations, and reduces launch costs
- Invest in a suite of promising technologies

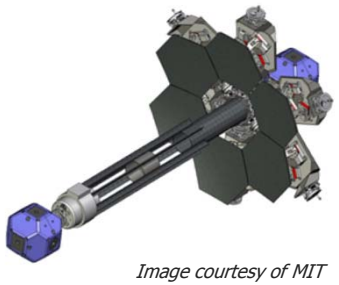


Image courtesy of MIT

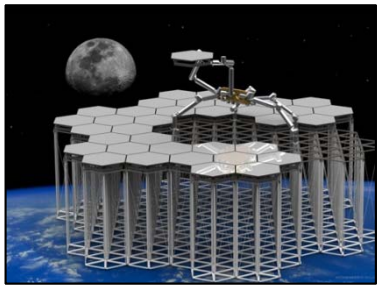


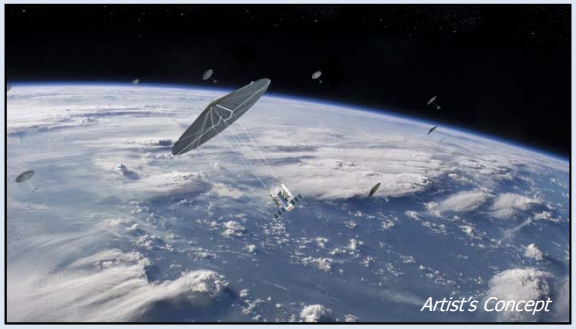
Image courtesy of JPL

Future Program Ideas and Interest Areas

Low SWaP, RF and Comms

Low-size, -weight, -power and -cost systems that enable high-resolution, ground based and space based imaging – to include RF and comms

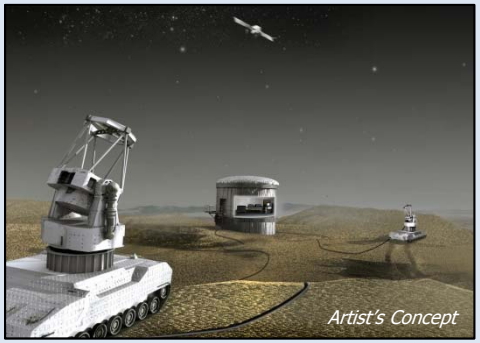
RadarNET (RNET)



High-Resolution Imaging from the Ground

Sensors or systems that fill a gap in our ability to identify, track and characterize small objects and debris in space

Newton (Galileo Follow-On)



International cooperation

Collaboration with international partners in the area of space situational awareness to both increase capability and share the burden

Orbit Outlook: International

Image courtesy of JAXA

TTO Proposers Day 2015

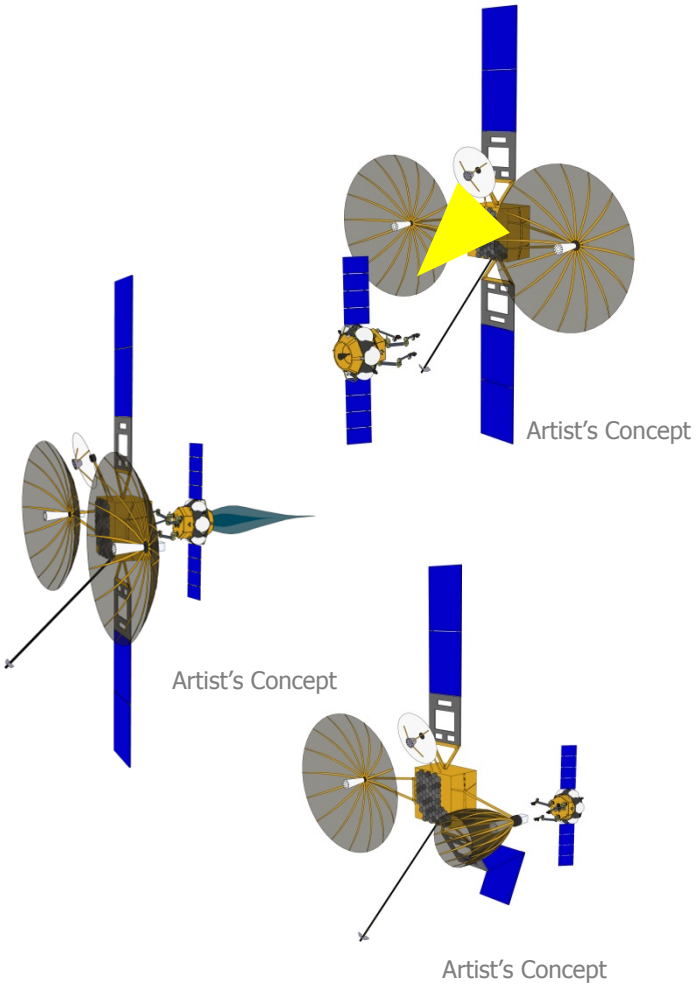
Dr. Gordon Roesler, TTO Program Manager

Briefing prepared for TTO Proposers Day

April 29, 2015

Current TTO Program

- Phoenix GEO robotic spacecraft servicing
- Goals
  - Introduction of robotics capabilities in GEO
  - Results in improved satellite utility, lifespan, resilience and reliability
    - Inspection of failed components
    - Deployment anomaly correction
    - Orbit adjustment
    - Deferred disposal
  - Lower satellite construction and deployment costs
  - Flexibility to accommodate multiple mission-critical on-orbit servicing missions (i.e. repair, repurposing, repositioning, etc.)



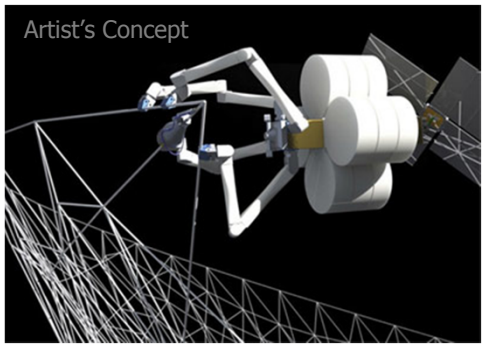
Artist's Concept

Artist's Concept

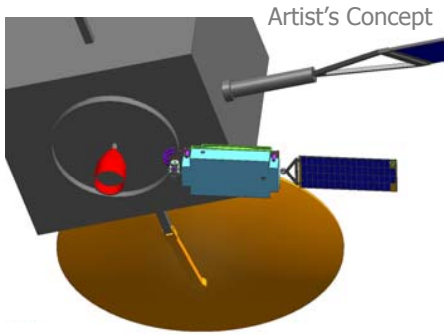
Artist's Concept

Interest Areas

- Robotic assembly of large structures and apertures
  - Military advantages (better link margin, smaller ground terminals, improved intercept, persistence at GEO, etc.)
  - GEO robotic servicer could act as prototype assembler
  - Architectures and key technology "long poles"



- Future space operations
  - What are optimal responses to the contested space environment?
  - What technologies will improve responses?
  - Synergies with robotics in GEO



- Wave avoidance structures for agile unmanned vessels
  - How can we use smart sensing and controls to improve the seaworthiness of a fragile but agile small craft?

TTO Proposers Day 2015

Mr. Jess Sponable, TTO Program Manager

Briefing prepared for TTO Proposers Day

April 29, 2015

Current TTO Program

Experimental Spaceplane (XS-1)

Technical objectives

- Reusable 1st stage, expendable upper stage
- Fly 10 times in 10 days
- Design for recurring cost ≤ 1/10 Minotaur IV
  - > 3,000 lb payload
  - < $5M/flight (sortie-like operations)
- Launch subscale orbital demo payload once
- Hypersonic test payloads flying at > Mach 10

Mission

- Responsive launch of small DoD and commercial payloads
- Enable DoD disaggregation and resiliency strategies

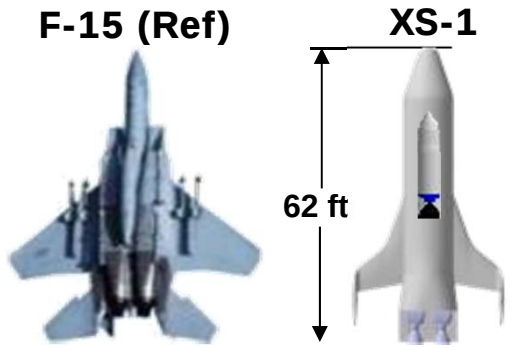
Artist's Concept

3 Prime Contractor Awards

Kick-offs: July 2014

7 Technology Awards
Propulsion, hot structures, cryogenic tanks, communications and GN&C

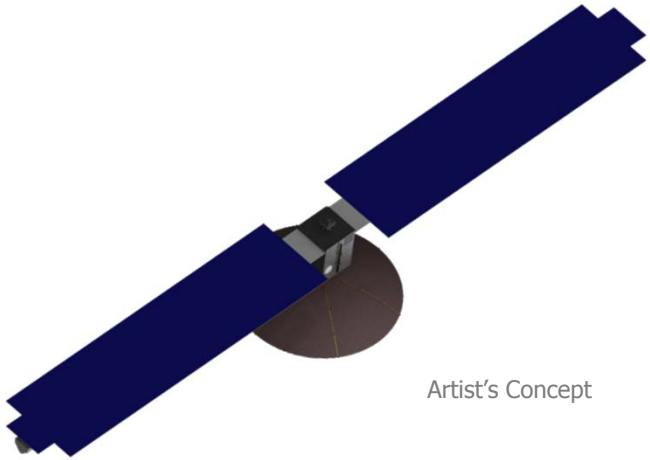
Approx Size Comparison



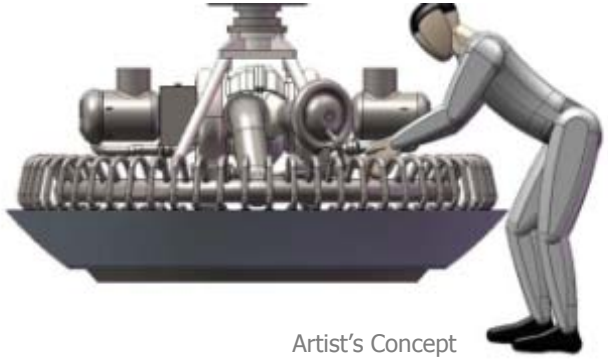
Gov't Reference Vehicle

Interest Areas

- **Space systems**
- **Solar-Electric Propulsion (SEP)**
  - Extreme maneuver capability
  - Resilient operations
  - Integral SEP enabling spacecraft downsizing
- **Next-Generation Rocket**
  - Novel cycles, modular architectures
  - Reusable, highly-operable 3rd generation rocket booster (3GRB)
  - Advanced/additive manufacturing
- **Advanced propulsion and power and engineering concepts with the potential to radically lower the cost of space access and enable new energy paradigms**



Artist's Concept



Artist's Concept

Space Panel Q&A

Mr. Mitchell Burnside Clapp

Lt Col Larry Gunn

Dr. Lindsay Millard

Dr. Gordon Roesler

Mr. Jess Sponable

Disclaimer

Reference herein to any specific commercial product, process, or service by trade name, trademark or other trade name, manufacturer or otherwise, does not necessarily constitute or imply endorsement by DARPA, the Defense Department or the United States Government, and shall not be used for advertising or product endorsement purposes

www.darpa.mil